# 3.0 Additional Items

The following items are included in section 3.0:

Section 3.1 *Illegal calls* – an introduction to appendix B on this subject

Section 3.2 *Response to Lucent Filing*

Appendix A – *Test Setup and Calibration*, for AirCell testing in the Marlboro areas in May 2003

Appendix B – *An Analysis of the Interference Effects of Illegal Airborne Cellular Telephone Calls*, John R. Doner

Appendix C – A review of Aircraft and Flight route geometry

## 3.1 Illegal Calls

### 3.1.a Overview

Contrary to both FAA and FCC regulations, each day, every hour, on a multitude of flights, on both commercial as well as private general aviation aircraft, pilots and passengers are making illegal calls using their handheld cell phones from aircraft while airborne. These illegal calls, when made, cause substantial interference to terrestrial cellular operations. And yet, the Opposition to AirCell has elected to not focus on mitigating this interference problem through: customer education, regulatory activity and optimized terrestrial antenna patterns to reduce signals from illegally calling aircraft.

> **It is interesting that the Opposition to AirCell has done nothing concerning these illegal calls- particularly those terrestrial carriers that operate narrowband services, i.e. AMPS and TDMA.**

During inquiries to Opposing carrier customer service centers, service representatives have indicated not only would the call likely work from an aircraft but that it was OK to place such a call. Even within the Oppositions' own organizations, there is no organized program to educate consumers to the dangers of making airborne calls with a handheld phone.

Similarly, the Opposing carriers do not have a sustaining regulatory program at the FCC and FAA to enforce agency rules concerning illegal call activity. Yet, these same Opposing carriers seem to be able to find the financial, legal and technical resources to "fight" a perfectly legal system that does not cause interference, namely the AirCell system.

Finally, if the Opposing carriers were serious about minimizing interference from illegal aircraft sources, they would have implemented programs to shape terrestrial cell site antenna patterns to dramatically reduce the level of upward looking antenna pattern side lobes. They have not done this despite the definite benefit such a program would realize for their terrestrial cellular operations.

### 3.1.b The effects of illegal calls

AirCell commissioned a study to examine in detail the effects of illegal phone calls from aircraft. This study, performed in June of 1998, remains relevant today. In fact, the growth of general aviation and cellular subscribers likely makes this study even more conservative today. That is, the impacts of illegal airborne phone calls on terrestrial operations are even more pronounced in 2003. This study is submitted herein for the first time into the record of this proceeding.

The attached study was conducted by Dr. John Doner, an esteemed mathematician with extensive professional experience in the field of wireless cellular telecommunications. Since actual field studies would have been illegal and would have caused interference to terrestrial cellular, Dr. Doner's methodology focused on extensive computer simulation with advanced theoretical probability analyses.[1]

While this study is focused on comparing illegal airborne AMPS calls to terrestrial AMPS calls, the study is directly transferable to the illegal airborne AMPS calls to terrestrial TDMA calls. For the reader to draw conclusions to TDMA, merely take the Signal-to-Interference (S/I) ratio listed in Dr. Doner's report and compare to studies which show where TDMA is impaired. For example, the industry uses an accepted 17dB separation for AMPS and TDMA[2].

The compelling conclusion of this study is startling, especially given the Opposition's lack of focus in this area.

For every illegal call from an aircraft over an Urban area:

> *"an illegal cellular call placed over an urban area during the period from 7 A.M. to 7 P.M. will on average interfere seriously with 1.45 legitimate AMPS calls, causing termination of 94% of the affected calls."*[3]

More specifically during busy hour over an Urban area:

> *"for each illegal airborne cellular call which is placed over an urban cell system at busy hour, 1.7 legitimate AMPS calls will be degraded or ended, and of those two categories, 16 out of 17 of the degraded calls will be degraded to the level that they must be terminated."*[4]

Dr. Doner clearly points out that if the "ambient interference in the terrestrial system" is included, the above statements become even worse in terms of their impact to terrestrial cellular operations.

Last, if the terrestrial system de-allocates channels due to repetitive interference (from illegal call activity), the effects are stunning:

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[1] Independent surveys commissioned by AirCell indicate that at least 15% of all general aviation flights involve the initiation of illegal phone calls. And, like many surveys that query the use of an illegal activity, the known bias is generally towards an actual number that is greater since many respondents will decline to answer truthfully regarding their (illegal) activity.

[2] WSE indicate that TDMA becomes impaired at a lower inter-system isolation. See WSE studies submitted by AirCell to the Commission for more information.

[3] "An analysis of the Interference Effects of Illegal Airborne Cellular Telephone Calls", Dr. John Doner, p.5

[4] Ibid

> *"a single illegal airborne call will adversely affect an average of 3.95 customers, either by seriously degrading their call (usually causing termination), or preventing access to the system in the first place."*[5]

Dr. Doner makes a compelling case that illegal call activity has a serious impact to terrestrial operations. More important, being a pilot himself, he goes on to say quite logically:

> ***"Cellular providers should therefore welcome the AirCell, Inc. product, which provides a legal means to provide pilots and their passengers the capacity to make cellular calls which effectively visits no interference on their systems".***[6]

One can only wonder when the opposition to AirCell will focus on the true problem, that is "illegal handheld call activity from aircraft," and embrace AirCell as a solution rather than an adversary.

[5] Ibid, p. 6
[6] Ibid

## 3.2 AirCell Evaluation of "Comments of Lucent Technologies, Inc."

Concurrent with the lengthy V-Comm submittal, Lucent Technologies Inc., filed comments in this proceeding. The stated intent of Lucent's filing is to acknowledge that Lucent did provide technical support to V-Comm during the Phase 1 and Phase 2 testing. This support amounted to:

- Review of the V-Comm test plan.
- Guidance regarding operation of Lucent equipment.
- Assistance in the mechanical gathering of data with switch based software (although Lucent acknowledges in Section 1.0 that they did not directly participate in test procedures or data collection).
- Providing some amount of post-processing support of switch based measurements.
- Providing guidance on analytic methods.
- Performing spot audits of V-Comm during the process.

AirCell has reviewed the Lucent comments, which provide some interesting generalities. It appears that the intent is to provide credibility to the V-Comm report by associating an implied stamp of approval from a respected industry member, Lucent Technologies Inc.

AirCell and our provider partners own and operate a significant amount of Lucent equipment in our cellular network, and are quite familiar with the Lucent tools and methods referred to in the document. In addition, employees of both AirCell and WSE have a substantial body of experience with Lucent equipment as deployed in numerous other terrestrial cellular networks. Based on this experience base, we can critique the content of the Lucent paper.

The first issue that should be raised is the fundamental misapplication of the Lucent PLM2 tool. Lucent documentation, which V-Comm conveniently ignores, specifically describes the proper use of the tool, yet V-Comm did not do so (which is explained at length in section 2.2). We are astounded that, if Lucent was actually auditing the V-Comm work, they would not have at least commented about this gross error, rather than condoning it by their supportive document. AirCell notes that the Opposing Carriers are significant customers of Lucent, a fact that may have been too hard to overlook for the unnamed drafters of the comments.

In Section 3.2, the paper states that:

> *"Lucent also suggested a means of processing data that was consistent with the sample sizes demanded (i.e., the need to characterize a number of metrics at a large number of injected interference levels). For example, Lucent suggested the need to fit trend lines to the data. This process, coupled with the physical knowledge that performance degradation must monotonically increase with interference levels, increases the statistical significance of the results."*

AirCell must point out that the V-Comm data is not monotonic, although the report shows some attempts to fit a least squares curve to data that is not monotonic in behavior. The above Lucent comments indicate that even they noticed the errors due to insufficient sampling. It must be noted that uncontrolled variables and selective sampling also can contribute to the unpredictable trends shown. Apparently, V-Comm did not follow this guidance from Lucent when preparing and executing the test plan.

Footnote 5 of the Lucent comments states that:

> *"Some equipment did not register measurement readings below –120 dBm. It is likely that these reading (sic) indicate interference levels below –120 dBm."*

AirCell provides significant evidence that the methods employed by V-Comm have significant flaws. In this footnote, Lucent provides acknowledgement of the limitations of their equipment. On the basis of this statement, it is absolutely wrong for V-Comm to present noise floor measurements on the order of –120 dBm to –130 dBm in their report. The measurement equipment is not up to the task.

In Section 4.2, Lucent takes great care in pointing out that

> *"Typically, the specified (warranted) noise floor is –124 dBm/30kHz."*

Clearly any indication of a noise floor below –124 dBm is not considered valid by Lucent, yet V-Comm determines that the typical noise floor is below this level for Rural, Suburban and Urban environments. V-Comm appears to ignore the guidance provided by Lucent, and insists on presenting data that is extrapolated beyond the valid linear capability of the test equipment.

In Section 4.3, Lucent confirms the value of C/N+I used by AirCell. Where AirCell has traditionally used a value of 17 dB, Lucent offers an approximation of "16 to 18 dB." Further, Lucent correctly states that the total interference to consider, $I_{total}$, is comprised of the sum of receiver noise, $I_0$ and *co-channel interference*, $I_{co}$. It can be shown with certainty that the V-Comm report misinterprets these two effects, and erroneously represents the receiver noise as the total interference. This is done despite this very clear guidance provided by Lucent Technologies.

Section 4.4 of the comments states that:

> *"The lowest levels of interference that can cause statistically significant performance degradation are best observed from the TDMA tests. Values of interference in the vicinity of –117 dBm to –114 dBm caused degradation in blocked call rate. Note that these values are approximately 7 to 10 dB above the AMPS noise floor."*

This appears to be a restatement of the values reported by V-Comm in their flawed Phase 2 TDMA drive test. What the Lucent reference actually states is that the thermal noise floor of the AMPS (not TDMA) site is reportedly –124 dBm, and that simulated Continuous Wave (CW) FM signals are injected at –117 dBm to –114 dBm. It is inferred that there is absolutely no co-channel interference during this drive test, counter to the Lucent claim in Section 4.3. The most glaring omission in this statement is the received signal level of the TDMA calls that are being blocked. This assessment has no credibility in the absence of information about the true C/I of the victim calls.

Section 4.5 of the Lucent comments begins by stating (emphasis added):

> *"The data gathered during tests of the kind described above can show the level of interference required to impact performance; however, **this information alone does not add insight into the performance impact of existing systems**. For example, in order to state whether the AirCell mobile would interfere with a cell it flies over, **a number of considerations must be addressed**. **These include** the distance (path loss) from the aircraft to its serving AirCell site (which dictates **the level of transmit power**), the altitude (path loss) between the aircraft and the cell site receiver (which determines **the level of interference received**), the types of antennas used at the cell site (see section 4.6), **the probability that the AirCell mobile being used is co-channel to an active channel at the cell site, and the probability that the AirCell mobile is active** (i.e., a call is in progress). **The probability that multiple aircraft employing AirCell mobiles are within interference distance of the cell site** must also be considered. Lastly, **the threshold for system degradation** (i.e, the number of cells affected, and **the duration of the effect**) must also be considered."*

AirCell can appreciate this description of methodology provided by Lucent. In fact, it is a lucid description of the testing and analysis provided by WSE in the AirCell cross-technology interference test, as well as the 1997 Test Report. However, Lucent later states that:

> *"In order to illustrate possible interference effects, V-COMM used an approach similar to that described above."*

In stark contrast, the approach taken by V-Comm did not follow this Lucent-recommended approach at all for the following reasons:

- Erroneous values of AirCell transmit power, derived from the flawed Phase 1 report, were used in the V-Comm analysis.
- Exaggerated levels of received interference were used in the V-Comm analysis.
- Simplistic assumptions used in the V-Comm case study effectively assumed probability of being co-channel to be greater than 100%.
- The V-Comm case study assumed the AirCell call to be active 100% of flight time.
- The V-Comm traffic study assumed that all AirCell equipped aircraft have active calls in progress, causing harmful levels of interference.

- Flawed Phase 2 V-Comm tests, resulting in improper measurement of the Interference Threshold Level.
- Improper statistical models ignored duration of the incident AirCell signal levels received at terrestrial cell sites, assuming that worst case conditions exist continuously, regardless of the true dynamic performance.
- Lucent fails to mention that a major variable to the interference equation is the operating points of the victim cell sites. The configuration used to obtain the V-Comm Phase 2 data is wholly unrepresentative of the cellular world in general.

It is obvious that, despite the guidance provided by Lucent, V-Comm chose a different approach, gathered completely erroneous results, and employed totally improper analysis to arrive at their incorrect conclusions.

Section 4.7 of the Lucent comments states that (referring to an attached Appendix A, *Impact of External Interference on CDMA*):

> *"The study suggests that if system capacity is to remain constant, the effect of an external noise power of –109 dBm – equal to the assumed receiver noise floor of –109 dBm – will demand a 30% cell coverage reduction. A second example shows that if the strategy is to maintain cell size, external noise equal to the noise floor of –109 dBm demands a capacity loss of 82%."*

There is a critical factor that is omitted from this statement. It is only true if the source of interference is spread across the same bandwidth as the CDMA channel. That is, the interferer, to cause such an effect, would have to be at a level of –109 dBm over a bandwidth of 1.25 MHz. In this case, the interference would sum with the noise to create a noise plus interference level 3 dB higher, or –106 dBm. We are astounded that Lucent would word this statement such that it could be so easily misinterpreted that their dBm numbers apply to 30 kHz interferers. Clearly V-Comm misinterpreted it.

A narrowband carrier of 30 kHz bandwidth, injected into a 1.25 MHz bandwidth channel with noise floor of –109 dBm will not raise the noise floor by 3 dB as implied in the Lucent comments. The interferer noise power must be spread from 30 kHz to 1.25 MHz, a factor of 41.67, equivalent to 16.2 dB. Thus a 30 kHz carrier at –109 dBm would be equivalent to a 1.25 MHz carrier at –125.2 dBm. The resulting rise in the noise floor would be 0.1 dB. This was definitively proven in the tests performed by WSE and reported in *AirCell/CDMA Compatibility Test*, previously submitted to the Commission.

Section 1 of Appendix A of the Lucent comments, *Impact of External Interference on CDMA*, states (emphasis added):

> *"Pre-commercial spectrum sweeps can determine the level of external interference present within the CDMA system.* ***Full spectrum clearance can yield maximal capacity and coverage****; however, if spectrum cannot be cleared,* ***the***

> ***presence of external interference can be compensated for in design*** *through sacrifice of capacity and/or coverage. Such design solutions, although valid, are generally not considered acceptable by operators since this strategy implies that scarce,* ***expensive radio spectrum is not being used to its full potential****."*

AirCell agrees wholeheartedly with these statements. In fact, through the very design of the AirCell network, great care has been taken to ensure that incident AirCell signals do not affect the quality, or the capacity/coverage tradeoff of terrestrial cellular band CDMA systems. Sufficient proof was provided in the *AirCell/CDMA Compatibility Test*. In addition, the novel and successful approach that is used by AirCell provides a means of using expensive radio spectrum to its full potential.

Section 1 of Appendix A of the Lucent comments, *Impact of External Interference on CDMA*, also states:

> *"For example, a narrowband interferer of –115 dBm degrades cell coverage relative to that achieved by clean spectrum by 10%. If this interferer cannot be removed, the network can still achieve full capacity provided that the design coverage is reduced by this amount. Note that, strictly speaking, this interpretation can apply only to steady-state sources of interference, since – by definition – transient sources are difficult to capture or characterize, thus making it impractical for their impact in design."*

The conclusion about the effect of a *narrowband* interferer is incorrect. This value of 10% capacity reduction is read from Figure 1. The x-axis of this plot is labeled "External Interference Power (dBm/1.23 MHz) Received by CDMA BS". A narrowband carrier, for instance an AMPS carrier of 30 kHz, has much less impact. If spread over 1.23 MHz, the effective impact is 16.1 dB lower. Thus, the curve of coverage must be shifted to the right by 16.1 dB to show the equivalent impact of an interferer of 30 kHz bandwidth.

The analysis assumes a CDMA noise floor of –109 dBm/1.23 MHz. If an interfering, steady state carrier of –115 dBm/1.23 MHz were summed with the noise floor, the resulting N+I level would be –108 dBm/1.23 MHz, or a 1 dB rise. According to the Lucent figures this would result in a coverage reduction of approximately 10%, or a capacity reduction of approximately 20%, or a combination of the two reductions. This is correct for a 1.23 MHz wide interferer, but not for narrowband AMPS.

Fortunately, these Figures can be used to find an equivalent factor for a narrowband interferer, for instance one of 30 kHz bandwidth. What level of narrowband interferer would result in a 1 dB rise in CDMA noise floor, from –109 dBm/1.23 MHz to –108 dBm/1.23 MHz? That would be –98.9 dB. This is 16.1 dB higher than an interferer of 1.23 MHz bandwidth. These values are consistent with the results of the WSE report *AirCell/CDMA Compatibility Report*.

The additional commentary in the Lucent report correctly states that this reduction in coverage or capacity assumes a constant interferer, rather than a transient one. This further reinforces the conservative approach taken by WSE. The environment that aircraft operate in is dynamic, and the incident signals from AirCell transceivers received at terrestrial base stations are not continuous.

Section 2 of Appendix A, *Impact of External Interference on CDMA*, states:

> *"It is observed that an external interference power of –105 dBm/1.23 MHz will cause about 5.5 dB noise rise and 51% cell coverage loss. As the average external interference power is –120 dBm (11 dB below the typical receiver noise floor, -109 dBm/1.23 MHz) causing a 0.3 dB noise rise, then the cell coverage reduction becomes about 4%."*

Again, the author erroneously assumes that an interferer of –120 dBm would cause a rise in the CDMA noise floor of 0.3 dB. This is only true if the interferer is –120 dBm/1.23 MHz. An interferer of –120 dBm/30 kHz would cause a noise floor increase of less than one one-hundredth of one dB. This is negligible, and not even perceptible with the most sensitive of measurement equipment. It would cause absolutely no impact on call quality, cell coverage or cell capacity.

AirCell understands that Lucent Technologies Inc. is a leading provider of cellular base station equipment, and has the internal expertise to conduct measurements and analysis. It is noteworthy that no author of this document is cited; perhaps multiple authors contributed to this paper. This omission makes it difficult to trace the source of this material back to anyone, much less any person of responsibility at Lucent Technologies, in order to evaluate the credentials of the source. The unknown author of this testimonial seems to misunderstand some basic concepts of CDMA spreading and despreading that are critical to determining the interference impacts. Apparently, the experts at V-Comm share this myopic misunderstanding, as it conveniently would reinforce their erroneous conclusions.

***The above critique will serve to set the record straight about the V-Comm Phase 1 and Phase 2 testing, along with the associated Case Study. In fact, if taken correctly, much of the Lucent commentary actually <u>supports</u> the AirCell/WSE testing, and <u>refutes</u> the V-Comm conclusions.***

# Appendix A

# Test Setup and Calibration

## a. Introduction and Background

Major issues raised in the V-Comm report included those of typical reverse operating point (reverse channel received signal strength at the base station), and the noise floor against which the received signals must compete. The levels reported by V-Comm were quite low in both cases, and in disagreement with previous reports submitted by TEC Cellular, WSE, and AirCell. To provide corroboration for previous reports, and to evaluate the accuracy of V-Comm assertions in the locations V-Comm tested, a test program was devised.

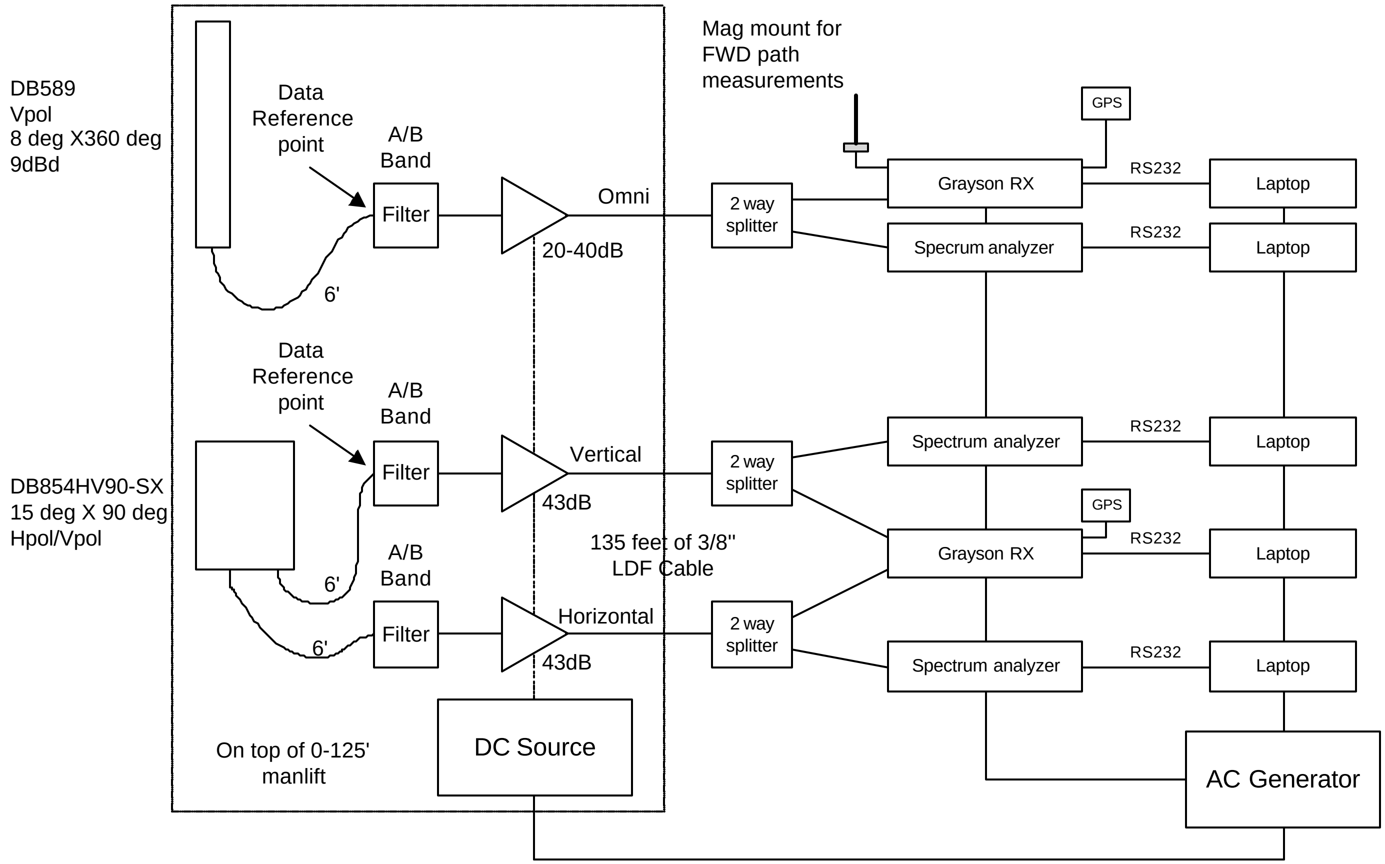
WSE and AirCell organized a test to provide signal and noise floor data at the Marlboro and Oak Hill sites as well as several areas near Philadelphia mentioned in the V-Comm report. As access to the sites themselves was unlikely to be granted (they are owned/operated by Cingular and Verizon – parties in opposition to AirCell) it was necessary to arrange data collection from a point outside the sites. A mobile test setup was devised using a 125' manlift, which allowed the test antennas to be placed at the same level as the radiation centerline of the Cingular/Verizon sites, and in close proximity. Data was collected using equipment in a minivan at ground level. This quickly organized test had limited success at sites which included a Nextel collocation, apparently due to intermodulation and spurious signals, but served to confirm both CDMA and TDMA operating points and noise floors, as viewed by both Vertical and Horizontally Polarized apertures.

## b. Equipment Configuration

The collection equipment compliment is shown in block diagram form in Figure A.1 below. The omni and dual polarization panel antennas were mounted to the bucket of the manlift; an omnidirectional vertically polarized DB-589, and a dual-polarized DB854HV90-SX.

As measurement of the noise floor was part of the objective, it was critical that the measurement system noise floor be as low as possible. To assure this, preselect filters and preamplifiers were placed in the bucket with the antennas (setting the noise figure before any significant losses), driving roughly 135 feet of 3/8" LDF cable leading to the equipment in the minivan below. A source of clean DC power was placed in the bucket of the manlift (batteries on a float charger) to power the preamplifiers.

The Grayson receivers in Figure A.1 were used to monitor TDMA and AMPS reverse channel activity using three parallel signal paths. The fourth Grayson receiver path used a mag-mount antenna placed on the van, to monitor forward channel activity. Forward channel activity above a certain power threshold indicated that the voice channel was active, and that the reverse channel carried a simultaneous subscriber call. Absence of forward channel power indicated that no subscriber call was present on the channel at the site, so the data taken on the reverse channel represented the operating noise floor.




Grayson RX

- Measure FWD path and detrmine frequency plan
- Measure FWD and REV path data

Spectrum analyzer

- Measure CDMA channels
- Measure noise levels

**Figure A.1 Block diagram of test setup**

The spectrum analyzers used were HP 8594E units.  These were used to monitor reverse channel CDMA operating point (composite noise floor produced by CDMA subscriber traffic plus man made and thermal noise).  These analyzers were controlled by custom WSE software.  This series of spectrum analyzers takes 401 amplitude measurements in each sweep, which appears on the screen as an essentially continuous trace.  The software dumped and saved a full sweep from each analyzer approximately every 2 seconds, saving all 401 amplitude measurements from the sweep.  This amounts to saving a 'screen shot' every two seconds for later analysis.  This procedure differs from that used in the 1997 TECC test, in which only 5 frequency/amplitude pairings were saved per second.

The monitoring equipment setup is shown in Figure A.2.

**Figure A.2  Monitoring equipment at ground level**

The three spectrum analyzers and their associated data collection computers are at top left, while the two (Gray) laptops at right were used to run the Grayson receivers, barely visible between the rows of seats at bottom left of Figure A.2.  Figure A.3 shows the Grayson receivers more clearly.  The 3/8" cables entered the van through the left rear window, and the power splitters used approximately 36" cables to feed the analyzers and Grayson receivers.  The power splitters are near the top center of Figure A.3.

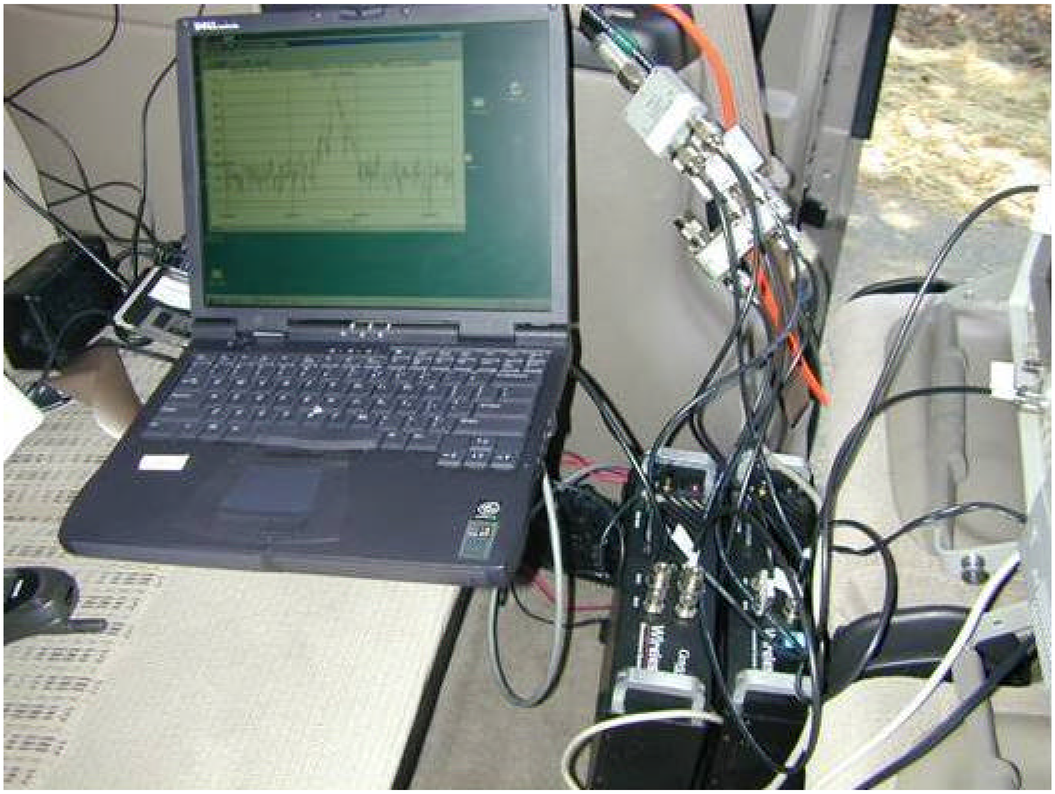


**Figure A.3 Closeup of Grayson receivers and power splitters**

The antenna installation on the manlift is shown at the Marlboro site in Figure A.4:

**Figure A.4 Manlift with test antennas in place at Marlboro site**

A closeup of the test antennas mounted on the manlift bucket is shown in Figure A.5.

**Figure A.5 Antenna installation on manlift bucket**

Initially, the preamplifiers for each path were to be identical MA-COM model AM-1383AM units (typically found in Lucent receive multicouplers). These have a high gain, a high intercept point, and a low noise figure. However, one was found to be faulty (unusually low gain) during the initial calibration. This left two functional MA-COM preamplifers, which were then used for the Vertical and Horizontal paths from the panel antenna. The 'odd' path was populated by either one Mini-Circuits ZFL-1000LN or two cascaded units with a 2 dB SMA pad in between for interstage impedance stabilization.

To eliminate forward channel saturation of the preamplifiers, preselect filters were necessary to reject the forward channels and pass the reverse. The filters used were Micro-tronics model BPC11922. These filters were the same for all three paths.

As mentioned in other sections of this report, the omni antenna was problematical at sites having a Nextel co-location, for two reasons: First, while the bucket was positioned with the panel to the side and slightly ahead of the sector transmit antennas, effectively placing the site forward channel emissions in the backlobes, the omni antenna was always 'facing' the site transmit antennas. This, plus the lower intercept point of the Mini-Circuits amplifiers, plus the fact that the bandpass filters didn't completely exclude the Nextel trunking radio signals, yielded intermodulation products and preamplifier saturation, rendering the omni data essentially useless. To combat this, only one Mini Circuits amplifier was tried, cutting the preamplification by about 20 dB, but even then saturation was a problem and the omni data was not well behaved. Even at sites not having a Nextel co-location, some saturation appears to have occurred, rendering the omni data questionable. Thus, the omni data is essentially ignored in the body of this report as less than reliable.

**c. Calibration**

The RF path was calibrated to determine the end-to-end gain between the point at which the 6' antenna jumper plugged into the filter/preamplifier assembly (designated 'Data Reference Point' in Figure A.1) and the cable-end connector which actually plugged into the appropriate spectrum analyzer or Grayson. This calibration was carried out in two steps. The power splitters, including output cables, were measured, then the path from the 'Data Reference Point' to the power splitter was measured. The sum of the gains represented the entire path. Post-test calibration was also accomplished to ensure that no components drifted significantly on any of the six measured signal paths.

**Table A.1 Path gain measurements**

| Total Adjustments to Path: | | To Grayson | To Spectrum Analyzer |
|---|---|---|---|
| Omni-directional | 1 Amplifier | 15.1 dB | 15.5 dB |
| | 2 Amplifiers | 35.6 dB | 36.0 dB |
| Horizontal Polarization | | 33.0 dB | 33.0 dB |
| Vertical Polarization | | 33.7 dB | 33.7 dB |

The measurements above were taken using an HP 8594E with the tracking generator option. The measurements are shown to a *resolution* of 0.1 dB, but the guaranteed *accuracy* of the instrument is less; on the order of +/-0.5 dB.

In analyzing the data after the tests were concluded, it was noticed that the Grayson receivers appeared to respond differently to signals than to noise... Further investigation confirmed that even though the Graysons were used in their 'Linear Averaging mode', which should have produced correct results, they consistently underreported noise – such as that found in measuring the noise floor. This isn't a major surprise, as these receivers use the RSSI pin of a Signetics NE605 family chip to read amplitude, which wasn't designed as an instrumentation grade device. Grayson calibrates using a signal generator over temperature, effectively linearizing the response for single signals, but errors remain for noiselike ones.

To correct for this, measurements were made in a laboratory environment. Since the amplifiers and passive components offset the level at which input signals and noise are presented to the Grayson, these measurements utilized the entire path, including all cables. Signals were presented using an HP 8656B signal generator, and noise was presented using a Noise/Com PNG7112 Programmable Noise Generator. The correction factors determined for each path are shown in Table A.2

**Table A.2 Signal vs. Noise Grayson correction factors**

| | Vpol Panel | | Hpol Panel | | Omni w/20 dB amp | | Omni w/40 dB amp | |
|---|---|---|---|---|---|---|---|---|
| True Signal or noise level | tone | noise | tone | noise | tone | noise | tone | noise |
| -80 | 2.2 | -2.9 | 1.6 | -0.5 | 1.7 | 3.5 | 2.4 | 1.7 |
| -90 | 2.2 | 1.2 | 1.6 | 0.1 | 1.7 | 4.8 | 2.4 | 0.8 |
| -100 | 2.2 | 3.5 | 1.6 | 4.2 | 1.7 | 3.0 | 2.4 | 3.4 |
| -110 | 2.2 | 3.5 | 1.6 | 6.3 | 1.7 | 3.9 | 2.4 | 6.4 |
| -120 | 2.2 | 1.0 | 1.6 | 3.6 | 1.7 | 4.6 | 2.4 | 4.0 |
| -130 | 2.2 | 1.5 | 1.6 | 3.6 | 1.7 | 6.6 | 2.4 | 3.1 |

Thus, to go from a raw Grayson reading of -66dBm on the vertical panel, we would have first path gain correction: -66 - 33.7 = -99.7 dBm
Then, correct for Grayson response errors:
Since -99.7 is essentially -100, the corrected reading is 2.2 dB higher if the input signal is a tone; -97.5 dBm actual. Or, if the input is multiple signals (reuse or noise) the corrected reading is 3.5 dB higher; -96.2 dBm actual

**d. Test Procedure**

At each location tested, the manlift, cable assembly, and equipment van were interconnected and set up as shown in Figure A.1. The manlift was positioned to place the test antennas at the same radiation centerline used by the targeted sector, facing the same azimuth. The manlift was placed to the side and slightly forward of the sector antennas, to place the sector transmit antennas in the backlobes of the test panel antenna. This position was also chosen to minimize blockage of the normal antenna patterns for the sector antennas, so the presence of the manlift did not affect typical reverse paths for the sector under test.

A Grayson receiver was placed in a vehicle, and parked roughly 100-200 yards away from the site, in a location which had a clear view of the sector antennas for the sector to be tested. The vehicle was positioned roughly at the center of the sector in azimuth. The receiver in the vehicle was then used to scan for active forward channels. The channels identified at the highest (consistent) signal level, usually in the –50 to –60 dBm range, were identified as the channels active on that sector. This list was used to build a scan list for the Grayson receivers in the van, including both forward and reverse frequencies. Control channels in the 313-354 range were ignored as they would not have contained active calls, and ranges of forward channel activity identified as CDMA were excluded. TDMA control channels were eliminated in postprocessing, as they were identifiable only through their constant forward channel transmission. While this method did not guarantee that ALL sector voice channels would be identified, it provided a representative set composed of most of the active channels.

The Graysons in the van were then loaded with the appropriate scan lists, with forward channels being loaded into the receiver channel utilizing the whip antenna on the van, and corresponding reverse channels loaded into all other receiver channels.

The spectrum analyzers were used to check for forward CDMA channel activity, and then were set to scan the corresponding reverse channels.

After all frequency settings and scan lists were completed (identically for each of the three signal paths), recording was begun for a period of roughly 24 hours at most sites. This way, data was collected to include any busy hours and relatively idle late night times. As discussed in other sections, the variation in noise floor was quite apparent, especially in the CDMA spectrum analyzer data, as the noise floor (and CDMA operating point) clearly rose during busy hours.

The Grayson receivers time tagged data using GPS time. The spectrum analyzer control computers were manually set to synchronize their system times with GPS time before recording started. This allowed later time alignment of the forward channel data with any or all reverse channel data. This time alignment was critical in determining the times and channels containing active TDMA calls.